This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Library
of the
University of Wisconsin

University of Wisconsin Library

Manuscript Theses

Unpublished theses submitted for the Master's and Doctor's degrees and deposited in the University of Wisconsin Library are open for inspection, but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publication of the thesis in whole or in part requires also the consent of the Dean of the Graduate School of the University of Wisconsin.

This thesis by.....................................
has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its patrons is expected to secure the signature of each user.

NAME AND ADDRESS DATE

M5901

THE DECOMPOSITION OF RED OAK WOOD BY *Fomes applanatus* AND OF RED SPRUCE BY *Trametes pini* var. *abietis*

By

ERNEST JOHN PIEPER

A THESIS SUBMITTED FOR THE DEGREE OF

MASTER OF ARTS

UNIVERSITY OF WISCONSIN

1915

AWM
.P5982

INTRODUCTION.

With the increasing development of forestry in the United States the problems concerned in the decay of timber, both in the living tree and after the trees are cut, are becoming more and more important. While the pathologist has already described, on a histological basis, many of the different types of rot caused by various wood-destroying fungi, very little has been done up to the present time which would give us an accurate knowledge of the change in chemical composition of the decayed wood.

In order to understand the chemical action of the fungus on the wood, it is first necessary to know the chief constituents of wood. These may be classified as follows:

- WOOD.....
  - CARBOHYDRATES......
    - pentosans $(C_5H_8O_4)$
    - pentoses $(C_5H_{10}O_5)$
    - hexosans $(C_6H_{10}O_5)$
  - LIGNOCELLULOSE.....
    - lignin = R
      - acetyl (CH_3CO)
      - formyl (HCO)
      - methoxy (CH_3O)
    - cellulose $(C_6H_{10}O_5)_x$
  - ASH - chiefly $(CaCO_3)$ and (K_2CO_3)
  - RESINS + VOLATILE OILS (in softwoods only)
  - CHROMOGEN substances (TANNINS, etc.)
  - PROTEINS (in very small quantities)

In the preceeding table R refers to the benzene nucleus which is combined with a carbohydrate. In wood-tar this is the source of phenols which give the tar in a large measure its toxic properties. It is seen that the chief constituents of wood are the lignocellulose and the carbohydrates. Lignin is here considered as the non-carbohydrate constituent of lignocellulose.

One of the most characteristic reactions of lignocellulose is its behavior towards the halogens. Lignocellulose takes up the halogens , which in this case is due to the presence of unsaturated bonds. Pure cellulose cannot be halogenated. Sodium sulfite dissolves out the halogenated product, that is the lignin, and leaves the cellulose unattacked.

Another characteristic reaction of lignocellulose is the absorption of phloroglucin. The proportion of phloroglucin absorbed is approximately in ratio with the quantity of lignin that is present.

The lignocelluloses give a series of characteristic color reactions with aromatic amines or phenols, which can often be used for a qualative determination. However, the color reactions with amines or phenols cannot be depended upon entirely, for there are more or less woody substances which give no color reactions. This has been definitely shown by Hancock and Dahl*. The same is true in the case of jute fibres which contain lignocellulose. After boiling the jute fibre with alkali, the ligno-

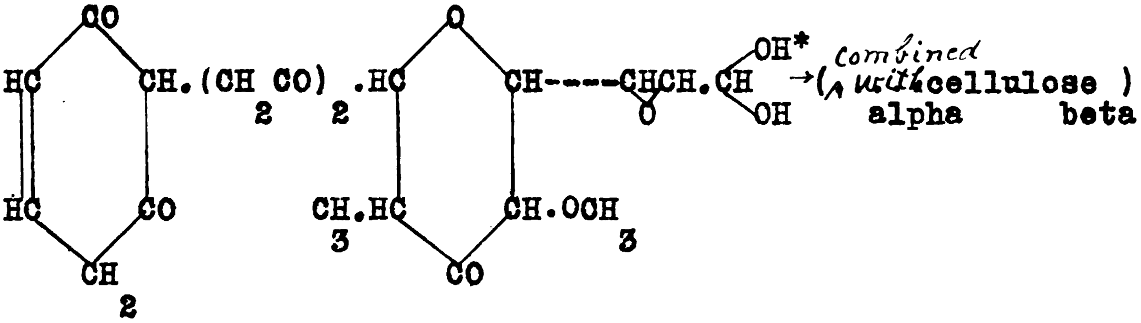
…………………………………………………………………………

* Berichte d. d. Chem. Ges. 29, 1558 (1896).

cellulose that remains gives no color reaction.

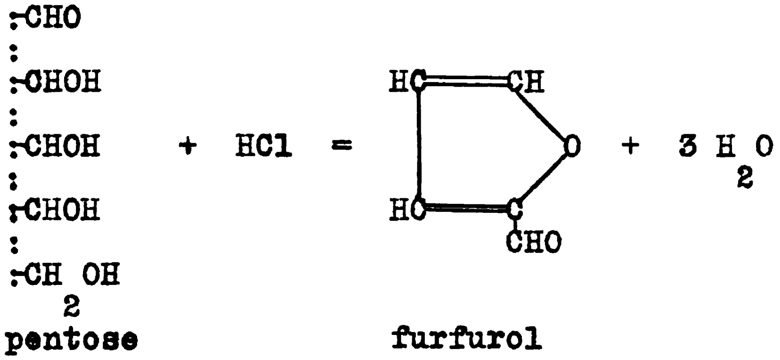
Since the lignin is not a simple and definite substance but an aggregate which varies in composition, it would be expected that these color reactions could not be used for quantitative determinations of lignin.

According to Cross and Bevan lignin consists of keto-hexene groups. These authors give the following formula as an approximate constitution of lignocellulose:



Thus the source of methyl alcohol, formic and acetic acids in the destructive distillation of wood is explained by the presence of acetyl, formyl and methoxy groups. Naturally the yields would vary with different woods, depending upon the composition of the lignin.

The pentoses and pentosans, occurring as wood-gums, and their methyl derivatives, yield furfurol and methyl furfurol on treatment with hydrochloric acid (sp. gr. I.06). The reaction is as follows:



Furfurol and methyl furfurol form insoluble phloroglucides. The methyl furfurol-phloroglucide, however, is soluble in ethyl alcohol, and can therefore be separated quantitatively from the furfurol phloroglucide.

The hexosans, in most cases, are found only to a small extent as a constituent of wood- galactan and mannan being the most important. Galactan can be determined by oxidation with nitric acid to mucic acid, while the mannan can be determined by hydrolyzing with sulfuric acid to mannose and precipitating the mannose as mannose-phenylhydrazone.

Knowing the chemical composition of the sound wood, we can therefor determine(~~the~~ change)the change in decayed wood produced by the fungus. The object of the present research has been to study the nature of these chemical changes due to the action of the fungus on the constituents of the wood.

PREPARATION OF MATERIAL.

A log of completely heart-rotted red oak about four feet in length, collected in the vicinity of Madison, Wisconsin, by Mr. M. C. Jensen, was the first specimen analyzed. This was thoroughly infected with Fomes applanatus -(Pers.) Wallr., and bore a large sporophore of the fungus at the base. About six months previous to the collection of the material, the tree had been broken off near the surface of the ground by a windstorm. The log selected for analysis was cut from the butt of the tree and was approximately eighteen inches in diameter. It consisted of decayed heart- and sap-wood and some sound sap-wood which comprised an outer shell from one to two inches in thickness. Uniform samples of sound and decayed wood, respectively, were prepared by the following method:

A good sample was selected and cut into saw-dust and then ground in a mill so that the material would pass through a forty-mesh sieve. The ground saw-dust was then put into a sealed container until ready for analysis. In the case of the sound wood, some very thin shavings were also prepared and preserved in a sealed container.

The specimen of decayed red spruce was thoroughly rotted by Trametes pini var. abietis, Karst. The material was collected by Mr. C. J. Humphrey in September, 1914, along the shores of Clear Lake, New York. The log selected was taken from the

trunk of a fallen tree approximately six inches in diameter. The tree had only the one fungus fruiting upon it. About a quarter of a mile off, a sound red spruce of about the same diameter as the decayed spruce was selected. The tree was cut about eighteen inches from the ground and a butt log four and a half feet long selected.

The decayed red spruce had thin strips of resin scattered in various parts of the wood. On microscopic examination of these resinous strips, they were found to be more or less penetrated by the mycelia of the fungus. On analysis, they were found to contain 37% of resin. These strips or pits of resin were discarded as far as possible, in selecting samples for analysis. The decayed wood was of such a consistency, that it it could be crushed between the fingers. The samples for analysis were prepared in the same manner as in the sase of the red oak. In both cases the wood was entirely freed from bark before analysis.

METHOD OF ANALYSIS.

The methods of analysis used in this investigation are those worked out and in some cases, modified by Mr. A. W. Schorger, of the Forest Products Laboratory. The method used for the determination of cellulose is a modified form of the chlorination method of Cross and Bevan*. The methods of manipulation have been so changed as to render the procedure more rapid and convenient. The use of the alundum crucible is especially of great assistance.

The Tollens method** for the determination of pentosan and methyl pentosan, as well as pentoses, has not been changed to any appreciable extent.

Methoxy determinations have not yet been made. A modified form of apparatus is now being constructed and as soon as it is completed, a series of analyses will be carried out, according to the Zeisel method.

MOISTURE.

Twenty-five grams of saw-dust from the sealed container are quickly weighed, (dry wood is very hygroscopic and should always be weighed in a closed vessel) placed in a 250-cc. flask, and treated with 75-cc. of water-saturated xylol. On distillation

---

* Jour. Chem. Soc. 55, 199 (1889).

** See B. Tollen's "Kurzes Handbuch d. Kohlenhydrate".

the water and xylol pass over together and are collected in a graduated funnel. The amount of water in cubic centimeters can be read off directly.*

In the case of hardwoods, where we have no volatile oil present, the moisture determination can be made directly by heating the saw-dust in an air-oven at 105° C. to a minimum weight, the first weighing being made after twenty-four hours heating and subsequent weighings after twelve-hour intervals of heating.

ASH.

Ten grams of saw-dust are incinerated in a shallow platinum dish in the electric oven at 300° C. The contents of the dish should be stirred occasionally, if necessary, to insure a complete combustion of the carbon. If the combustion is incomplete, the carbon will appear as a black, suspended material on treatment with dilute hydrochloric acid. In that case, it should be returned to the muffle until complete combustion has taken place.

PRODUCTS OF ALKALINE HYDROLYSIS.

It is often of great commercial importance to know the action of alkali upon various woods. The principal consti-

---

* U. S. Dept. Agric. Forest Service Circular #134.

tuents of the wood that are attacked by alkalis are the carbohydrates, resins, tannins, and the lignin in part. Of course, the cellulose will also be attacked after a time if the concentration of the alkali is great enough. The results from this determination gives us only the loss due to hydrolysis, and not the amount of each substance hydrolysed.

(a)-Two grams of dry saw-dust are placed in a 400-cc. beaker, covered with a watch-glass and 300-cc. of 1% sodium hydroxide added. The solution is allowed to remain at room temperature for 48 hours with frequent stirring. The saw-dust is then collected in a tared alundum crucible, washed, dried at 105° C. and weighed in a weighing-bottle. The difference in weight is the loss due to hydrolysis at room temperature.

(b)-Two grams of dry shavings are placed in a 250-cc. beaker, covered with a watch-glass and 100-cc. of 1% sodium hydroxide added. The solution is gently boiled for ten minutes and the vol-kept constant by the addition of boiling, distilled water. The solution should be stirred frequently to prevent bumping and excessive foaming. The shavings are then collected in a tared, alundum crucible, washed thoroughly, dried at 105° C. and weighed in a weighing-bottle.

(c)-The loss by hydrolysis by boiling the solution for one hour in place of ten minutes is determined in the same way.

SOLUBILITY IN WATER.

Certain carbohydrates and chromogen substances are the chief constituents soluble in water. In some woods they occur free and in others probably in the form of glucosides. Since they are not all dissolved or hydrolyzed by either cold or hot water, accurate quantitative determinations are not possible.

(a)-Cold Water Soluble- Two grams of saw-dust are placed in a 400-cc. beaker, 300 cc. of distilled water added and allowed to digest the wood, with frequent stirring for forty-eight hours. The saw-dust is then transferred to a tared. alundum crucible, washed with one liter of distilled water, dried at I05° C. and weighed in the weighing-bottle. The loss in weight is the percentage of wood soluble in cold water.

(b)-Hot Water Soluble- Five grams of saw-dust are extracted in a Soxhlet Extractor for five hours, or longer, if the water surrounding the shell is still colored. The shell and contents are then dried and weighed. An alundum shell is very useful. The loss in weight is the percentage of wood soluble in hot water.

VOLATILE OIL.

The volatile oil from coniferous woods consists chiefly of turpentine. Depending upon the species of wood, various other oils may be present, especially terpene hydrocarbons.

Ten grams of the saw-dust from the sealed container are distilled with steam for five hours. The saw-dust is then weighed. The percentage of moisture in the wood must be subtracted from the total loss to give the percentage of volatile oil.

WAXES, FATS AND RESINS.

In the majority of coniferous woods, the amount of waxes and fats is negligible, and the result of this determination can therefor be recorded as resin content.

Ten grams of saw-dust from the sealed container are extracted with ether in a Soxhlet Extractor, the amount of material extracted being determined by loss in weight of the sample. It is necessary to correct for the loss of volatile oil and moisture.

PENTOSAN AND METHYL PENTOSAN.

Two grams of saw-dust (for coniferous woods) or one to one and a half grams for hardwoods) are placed in a 250 cc. flask, provided with a separatery funnel and attached to a condenser. Add 100 cc. of 12% hydrochloric acid (sp. gr.1.06)* and distill at the rate of thirty cc. in ten minutes.

---

* The solution of hydrochloric acid is conveniently prepared as

Filter the distillate and as soon as thirty cc. are collected, thirty cc. of hydrochloric acid are added from the separatory funnel and the distillation is continued in this manner until 360 cc. of the distillate are collected. Add40 cc. of filtered phloroglucine solution that has been prepared at least a week previously by heating eleven grams of phloroglucine in a beaker with 300 cc. of I2% hydrochloric acid. After the addition of the phloroglucine the solution soon turns greenish-black. Let stand until next day, when the furfurol-phloroglucide will have settled to the bottom of the beaker. If a drop of the supernatant liquid gives a pink color with aniline acetate paper**, the precipitation of the furfurol is incomplete. A further amount of phloroglucine solution is then added and the beaker allowed to stand over night as above.

....

follows:

300 cc. of ordinary concentrated hydrochloric acid are diluted to a liter and cooled to room temperature with tap-water A hydrometer, reading I.06 is suspended in the acid and by adding a small amount of either acid or water, as necessary, the desired specific gravity, I.06, is easily obtained.

** The aniline acetate paper is conveniently prepared by dipping strips of filter-paper in a solution of aniline acetate. The latter is prepared by adding acetic acid drop by drop to a mixture of equal parts of aniline and water until a clear solution is obtained.

The mixture of furfurol-phloroglucide and methyl furfurol-phloroglucide is filtered througha tared, alundum crucible and washed with 150 cc. of distilled water, care being taken that not all the water is removed from the crucible until the very last in order to facilitate the filtration. The crucible is then dried for four hours in a water-oven and weighed in a weighing-bottle. The crucible is then placed in a modified Soxhlet Extractor and extracted with 95% alcohol until the alcohol that siphons over is colorless. This dissolves the methyl furfurol-phloroglucide, leaving the furfurol-phloroglucide unattacked. The crucible is then dried for two hours in the water oven and again weighed. The weight of the residual phloroglucide subtracted from the weight of the mixed phloroglucides gives the weight of methyl furfurol-phloroglucide. From the weights o of furfurol-phloroglucide and methyl furfurol-phloroglucide obtained, the amount of pentosan and methyl pentosan present in the wood are calculated from the tables of Kroeber and Tollens*.

CELLULOSE.

Two grams of oven dried shavings are gently boiled for thirty minutes in a 250-cc. beaker with 50 cc. of 1% sodium hydroxide solution, the volume being kept constant by the addition of boiling water. The shavings are then transferred to a tared alundum crucible and thoroughly washed with water, by using the suc-

---

* See Abderhalden- "Handbuch d. Biochem. Abbeitsmethoden", Volume II, pp. 137 and 154.

tion pump. The moist shavings are then returned to the 250 cc. beaker with a pointed glass rod, evenly distributed over the bottom and subjected to a slow stream of washed chlorine gas for one half to one hour, depending upon the kind of wood treated. The end of the tube delivering the chlorine gas should be about one-half of an inch above the shavings. After the chlorine treatment, the shavings are treated with a solution of sulfur dioxide in water until the chlorine odor disappears, transferred to the alundum crucible and washed with water. The shavings are again returned to the beaker with the glass rod, I00 cc. of 2% sodium sulfite solution added, and heated on the steam-bath for one and a half hours. The fibres are then transferred to the crucible and washed with water. The above treatment is seldom sufficient to remove all the lignin, so that the treatment with the chlorine gas and subsequent treatment as outlined above, is repeated until the fibres are practically a uniform white. The second and following treatments with chlorine should not be longer than fifteen to thirty minutes. After all the lignin has been removed, the fibres are given a final bleaching with a 0.I% solution of potassium permanganate and rendered colorless with the sulfur dioxide solution. The fibres are then thoroughly washed with water and dried to a constant weight at I05 degrees C. in the air-oven, the crucible being weighed in the weighing-bottle.

ACID HYDROLYSIS.

Two grams of saw-dust are treated with IOO-cc. of a 2.5% solution of sulfuric acid and gently boiled for three hours, using the reflux condenser. Let stand until cool, wash down the condenser with a little distilled water, transfer the contents of the flask to a 250-cc. graduated flask, fill to the mark, let stand for eight hours with frequent shaking and then filter. With a IOO-cc. pipette, transfer 200-cc. of the filtrate to a 500-cc. flask, treat the contents with a clear, saturated solution of barium hydroxide until just alkaline to phenolphthalein and add fifteen cc. of 85% phosphoric acid. It is necessary to neutralize the sulfuric acid with barium hyroxide as otherwise the organic matter in the solution will be charred before all the acetic acid is driven over, with the result that carbon dioxide, sulfur dioxide, etc., are evolved and pass into the distillate. The distilling flask is closed with a rubber stopper provided with a separatory funnel and a thermometer whose bulb extends to the bottom of the flask. The flask is so heated in an oil bath that the contents of the flask distill at the rate of about two drops a second. When the thermometer shows a temperature of II5 degrees C., the distillation should be carefully watched as a point will be reached at which the contents of the flask will foam up rapidly.. When the foam half fills the flask, 50-cc. of water previously placed in the

separatory funnel, are rapidly run into the flask and the distillation continued until the contents again reach the foaming stage as described above. At this point the oil bath is lowered, blowing upon the flask if necessary, to check the foaming ,and the distillation stopped. The distillate is then treated with a N/IO sodium hydroxide solution, by using phenolphthalein as an indicator. The titration should then be corrected by running a blank (the latter being about 0.30cc. N/IO sodium hydroxide), multiplied by five-fourths, since only 200cc were distilled and the product calculated as percentage acetic acid. In this hydrolysis some formic acid is split off along with the acetic acid, but the entire acidity may be calculated as acetic acid without appreciable error. Duplicates should check within 0.2 percent.

All distilled water used in this determination should be recently boiled to expel carbon dioxide.

The results of analysis on both the red oak and the red spruce are given below in tabular form. In order to make a logical comparison between the sound and the decayed wood, the results obtained were calculated on a dry weight, equal volume and equal ash content bases. At first sight,,calculations on an equal volume basis would appear to be the most the reasonable for comparison. But there is quite an appreciable shrinkage in the decayed wood which is not accounted for in the results. The ash content of the sound and the decayed specimens would vary only to a slight degree on an equal volume basis, provided no leaching has taken place and provided there is no similar effects produced by the fungus. Calculations on such a basis would therefore probably give us a more

accurate comparison.

The whole object of this research has been to determine the chemical changes which occur in a given volume of sound wood, subjected to complete decay by the fungi studied. The only basis upon which these changes could be determined with accuracy, would be to artificially rot known volumes of sound wood and determine quantitatively the exact residues in the decayed wood, basing all percentages upon the dry weight of the sound wood. Experiments have already been started in this laboratory along this line.

TABULATION OF THE RESULTS ON RED OAK.

SOUND WOOD		DECAYED WOOD		
Dry weight basis		Dry weight basis	Equal volume basis	Ash content basis
6.08%	Moisture	7.93%	3.10%	5.20%
22.10	(a) Cold alkaline hydrolysis	26.74	10.70%	17.90%
20.39	(b) -- " "	28.24	11.50	18.90
26.10	(c) -- " "	37.45	14.90	25.10
5.95	(a) Cold water soluble	13.56	5.40	9.10
7.06	(b) Hot " "	22.44	8.90	15.06
0.83	Ash	1.24	0.50	0.83
26.83	Pentosan	20.53	8.20	18.00
1.36	Methyl pentosan	2.79	1.10	0.91
51.11	* Cellulose	48.22	19.70	34.30
5.85	Acid hydrolysis	4.87	1.95	3.26

The specific gravity of the sound red oak is 2.5 times that of the decayed red oak.

* In the cellulose determination of the fungous wood, it must be borne in mind that the final product is not all cellulose, but also contains a little chitin.

TABULATION OF THE RESULTS ON RED SPRUCE.

SOUND WOOD		DECAYED WOOD		
Dry weight basis		Dry weight basis	Equal volume basis	Ash content basis
5.85%	Moisture	6.08%	2.03%	0.84%
0.25	Volatile oil	I.50	0.50	0.2I
0.49	Resin	5.55	I.85	0.76
5.20	(a) Cold Alkaline Hydrolysis	30.69	10.23	4.24
7.49	(b) -- " "	36.68	12.23	5.06
I.93	(a) Cold water soluble	14.29	4.76	I.97
4.08	(b) Hot " "	23.75	7.92	3.27
0.32	Ash	2.32	0.77	0.32
II.78	Pentosan	7.99	2.66	I.10
3.10	Methyl pentosan	3.19	I.06	0.44
58.08	Cellulose	41.71	I3.90	5.75
I.94	Acid hydrolysis	I.II ~~0.90~~	0.37 0.30	15 0.15

The specific gravity of the sound red spruce is 3 times that of the decayed red spruce.

The following table gives the change produced by the action of the fungus on the constituents of the wood. The results state the actual change that has taken place in a unit volume of sound wood.

	RED OAK	RED SPRUCE
Moisture	2.98%	3.82%
(a) Cold akaline hydrolysis	II.40	5.03*
(b) Hot " " (IO min.)	8.89	4.74*
(c) " " " (I hr.)	II,20	---
Volatile oil	---	0.25*
Resin	---	I.36*
(a) Cold water soluble	0.55	2.83*
(b) Hot " "	I.84*	3.84*
Ash	0.33	0.45*
Pentosan	I8.63	9.I2
Methyl pentosan	0.26	I.04
Cellulose	3I.4I	44.I8
Acid hydrolysis	3.90 ~~[illegible]~~	I.53 ~~I.[illegible]~~

*Denotes an increase while the other percentages denote a loss.

Disregarding the small amounts of ash, resin, volatile oil, tannins, etc., and calculating on the basis that the wood consists primarily of pentosan and methyl pentosan, cellulose and lignin, the following comparison can be made between the sound and decayed wood.

RED OAK

SOUND WOOD		DECAYED WOOD		
Dry weight basis		Dry weight basis	Equal Volume basis	Ash content basis
28.I9%	Pentosan and Methyl pentosan	23.32%	9.30%	I8.9I%
5I.II	Cellulose	48.22	I9.70	34.30
20.70	Lignin	28.46	7I.00	46.79

RED SPRUCE

I4.88	Pentosan and Methyl pentosan	II.I8	9.05	I.54
58.08	Cellulose	4I.7I	I3.90	5.75
27.04	Lignin	47.II	77.05	92.7I

From the tables it is evident that the cellulose and the pentosan are the chief constituents decomposed by the fungus. The reduction in pentosan is very marked. The pentosan, (often referred to as hemicellulose $(C_5H_8O_4)_x$)is therefore more easily attacked by the fungus. It must also be born in mind that the pentoses $(C_5H_{10}O_5)_x$ may occur in the wood in the free condition, and in the final analysis are recorded as pentosan. We have therefore in this paricular instance a higher percentage of lignin in the decayed wood than in the sound wood, which is an indication that the oxybenzene groups of the lignin have toxic properties. The fact that we do have a higher percentage of lignin in the decayed wood explains the higher yields of methyl alcohol from certain hardwoods when taken on adry weight basis. In other words the percentage of the meth-oxy group is greater inthe decayed wood and since the source of the meth-oxy group is in the lignin, the lignin content must therefore be greater as these analyses actually show.

Up to the present time very little work has been published dealing with the chemical decomposition of wood by fungi. The work has been practically confined to elementary analysis.

The following are references to the chemical literature:-

Schwalbe, C.G.-Chemie der Cellulose.
Czapek, F. -Biochemie der Pflanzen.
Tollens, B. -Kurzes Handbuch der Kohlenhydrate.
Euler, H. -Pflanzenchemie.
Wehmer, I. -Pflanzenstoffe.
Cross and Bevan-Researches on Cellulose-I-1895-1900.
" " " " " " II-1900-1905.
" " " " " " III- 1905 1910.
Konig, --Bestim. der Cellulose in Holzarten und Gespinfaser.

Approved: S. F. Acree

Professor of Chemistry
of Forest Products

89089882187

b89089882187a